

Applications of Geothermal Energy in Mineral Processing

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Introduction

- The formation of deposits of industrial minerals in the island of Milos is closely associated with the volcanic and hydrothermal activity of the island
 - Mining industry is an important energy consumer
 - Some mining activities occur close to geothermal resources
- ⇒ In certain regions geothermal energy may become an interesting alternative energy source

The scope of this presentation is to show some practical applications of geothermal energy for mining activities and to briefly present the geothermal applications and the geothermal situation in Milos Is.

Geothermal Energy

- Geothermal energy is thermal energy stored in the Earth.
- Practically, the term refers to thermal water or steam trapped at accessible depths (less than 5 km), which can be economically exploited.
- It is a reliable energy source, available day and night throughout the year.
- Geothermal energy is in general a sustainable, cost-effective resource, benign to the environment.
- Because of low energy content of the geothermal water, it is not feasible to locate geothermal plants more than a few kilometers from the wellhead.

Applications of Geothermal Energy

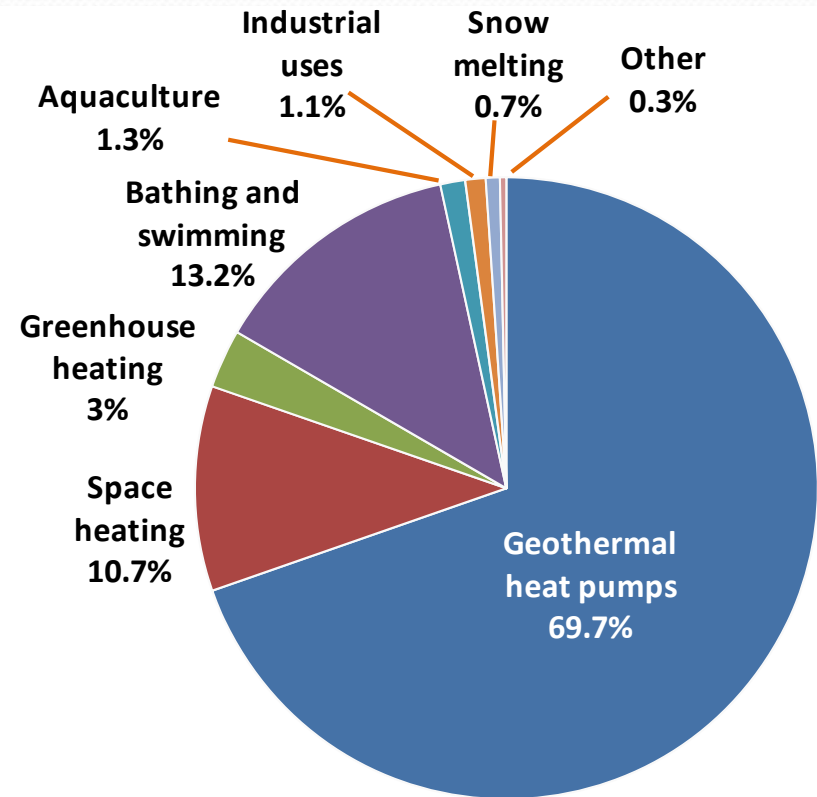
- Geothermal energy has been used for centuries for bathing, cooking or even heating, but it was in the early 20th century when large scale utilization started.
- The geothermal uses are commonly divided into two categories: **electrical uses** and **direct uses**.
- The high-temperature fluids are confined to certain areas of the Earth, associated with seismic and magmatic activity and young volcanism (e.g. California, Iceland, Larderello-Italy and **active Aegean volcanic arc**).
- **Direct uses:** waters with temperatures: 25 and 150 °C

Direct Uses

- Practiced in 78 countries
- Installed capacity (2010): 48.5 GW_t

Common categories of d.u.:

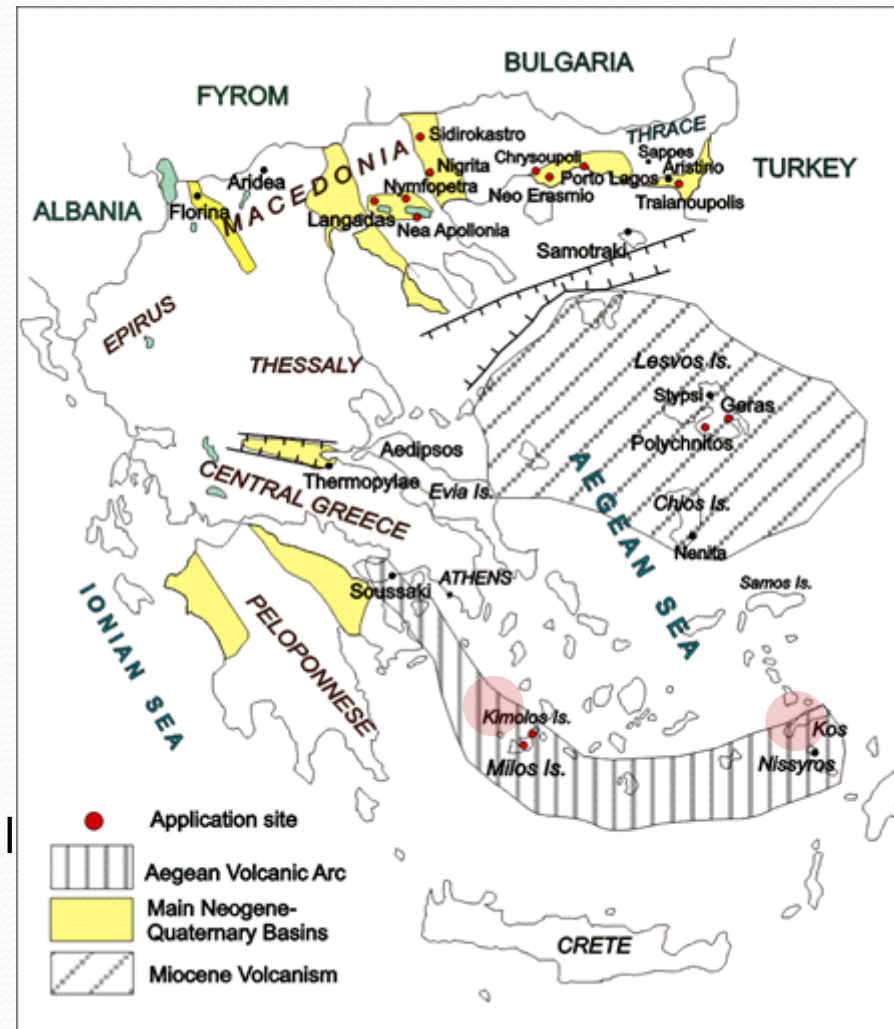
- space heating and cooling, including district heating;
- agricultural applications (greenhouse heating, soil warming etc.);
- aquaculture applications;
- industrial processes (including mining);
- swimming, bathing and balneology;
- geothermal heat pumps.



Geothermal direct applications worldwide in 2010, distributed by percentage of total installed capacity (Lund et al. 2011).

Geothermal resources in Greece

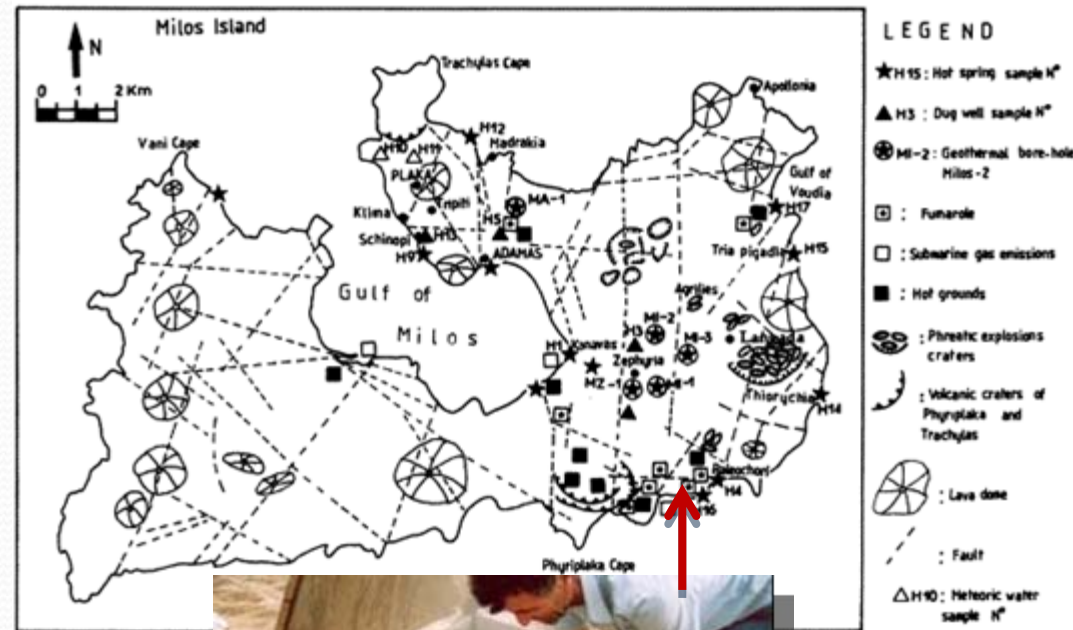
- Greece is rich in geothermal energy, a result of the movement of the African Plate towards the Eurasian one.
- IGME has carried out the bulk of geothermal exploration
- First activities in early 70s;
- High temp.: Milos & Nisyros Isl.
- Medium temp's: Lesvos, Chios and Samothraki Is., Nestos basin, Evros Basin
- Proven geothermal electricity potential 25 MW_e
- Proven direct uses potential: >1000 MW_t



Geothermal map of Greece.

Milos Island

- First geothermal exploration activity in Greece
- Milos is almost totally built up of volcanic rocks, while pre-volcanic units are observed in the southern part of the island.
- Surface thermal activity: springs with a max. temp. of 72°C, fumaroles with temperatures up to 102°C and hot grounds up to 102°C (geothermal cooking!)
- Wells at depths ~1200 m: T=240-320 °C
- Rate of each well: 50-150 m³/h



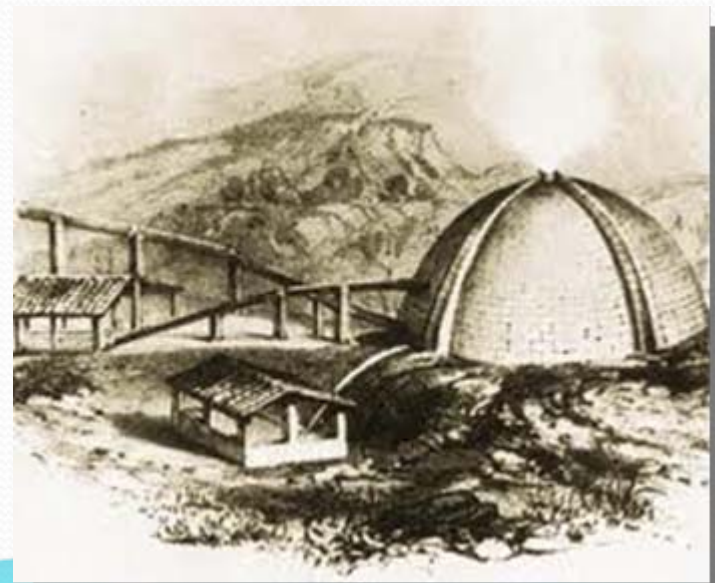
Geothermal applications in Greece

- Installed capacity (direct uses) : 155 MWt
- >100% increase compared with data for 2005. Mostly due to the rapid expansion of geothermal heat pump installations.
- The other uses rather stagnant
- Balneology accounts approximately to 25% of this capacity.
- Greenhouse and soil heating have the third largest share in the installed capacity. However, the total covered area of geothermal greenhouses has remained rather constant since 1995.
- Uses introduced during the past 15 years include fish farming, spirulina cultivation, and vegetable and fruit dehydration



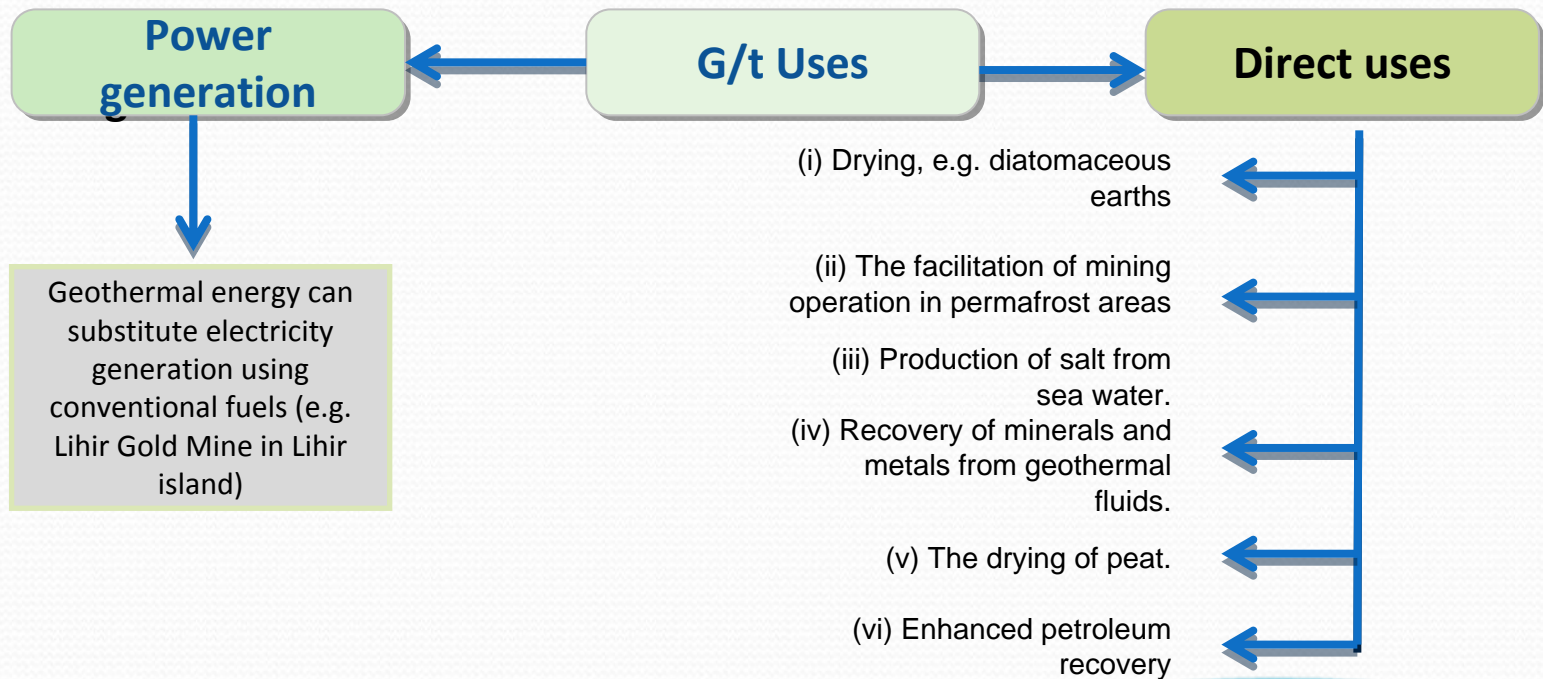
Industrial/Mining applications of G/t Energy

- Geothermal energy can be used in a plethora of processes pertaining to the industrial sector.
- Examples: process heating, drying, evaporation, chemical extraction, water desalination and power generation.
- The use of geothermal energy in an industry may be attractive provided that: (i) the cost of energy/kg product is lower than that currently used, (ii) the quality of geothermal heat is as good as the present supply and (iii) It is reliable through the life of the plant.
- Probably the first industrial use: the Etruscans extracted boric acid from the waters of Lagoons in Montecerboli.



Mining applications of G/t Energy

- There are several g/t uses in the sector of mining and upgrading of minerals.
- Some of them are simply potential uses (e.g. Lindal diagram), others were in operation for several years and others are still in use.



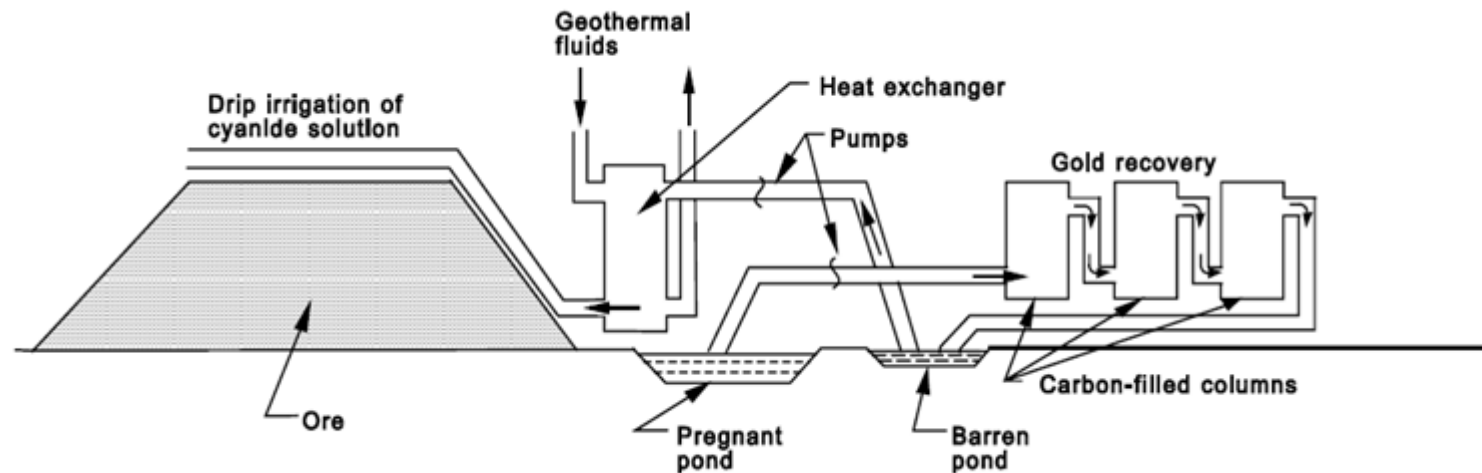
Drying of solid materials

- Drying (the raw-material or the product) is a very important operation in modern mineral and metallurgical processing.
- Geothermal energy can provide the required heat at much lower cost than conventional fuels.
- The first (and the largest) drying plant operated in Iceland from 1967 until 2004: the diatomite plant at Myvatn, near the Namafjall high-temperature field (N-E Iceland).
- It produced annually about 20-30 thousand tons of diatomite filter aids for export.
- The process required about 220,000 tons annually of geothermal steam at 10 bar.



Heap leaching

- Two mines in Nevada have used geothermal fluids in their heap leaching operations to extract gold and silver from crushed ore: Round Mountain Gold (starting in 1987) and the Florida Canyon Mine.
- Heating the dilute sodium cyanide solution increases the leaching rate and increases the operation season.



Idealized thermally enhanced heap leaching system (Trexler, et al., 1991).

Recovery of minerals from geothermal fluids

- Some geothermal fluids contain significant concentrations of some valuable minerals and metals.
- These solutions can be processed to recover certain minerals and metals, such as **silica, zinc, copper, antimony, lithium**, and other materials.
- A salt extraction plant was in operation on the Reykjanes Peninsula, Iceland, from 1974 to 1994.
- Silica: (i) A pilot plant in Wairakei (New Zealand) operated for 11 months producing colloidal silica; (ii) bricks and roofing tiles from a silica cement and silica-lime mixture (Mexico).
- Zinc recovery in Salton Sea, California and elsewhere.
- The geothermal waters in Russia may contain over 55% of the common stocks of lithium, 40% of rubidium and 35% of cesium (Svalova, 2010).

Water desalination

- In arid islands (e.g Milos, Is.), or areas with mining activities the access to fresh water is valuable. Geothermal energy can provide good quality desalinated water at very low cost.
- Thermal technologies: multistage flash distillation (MSF) process and multiple-effect distillation (MED).
- Low-enthalpy geothermal energy can be efficiently used in desalination via the MED process .
- A MED desalination plant constructed about 12 years ago in Kimolos Island. It utilizes low-enthalpy water (60-70°C) from shallow bores, 50-200 m.



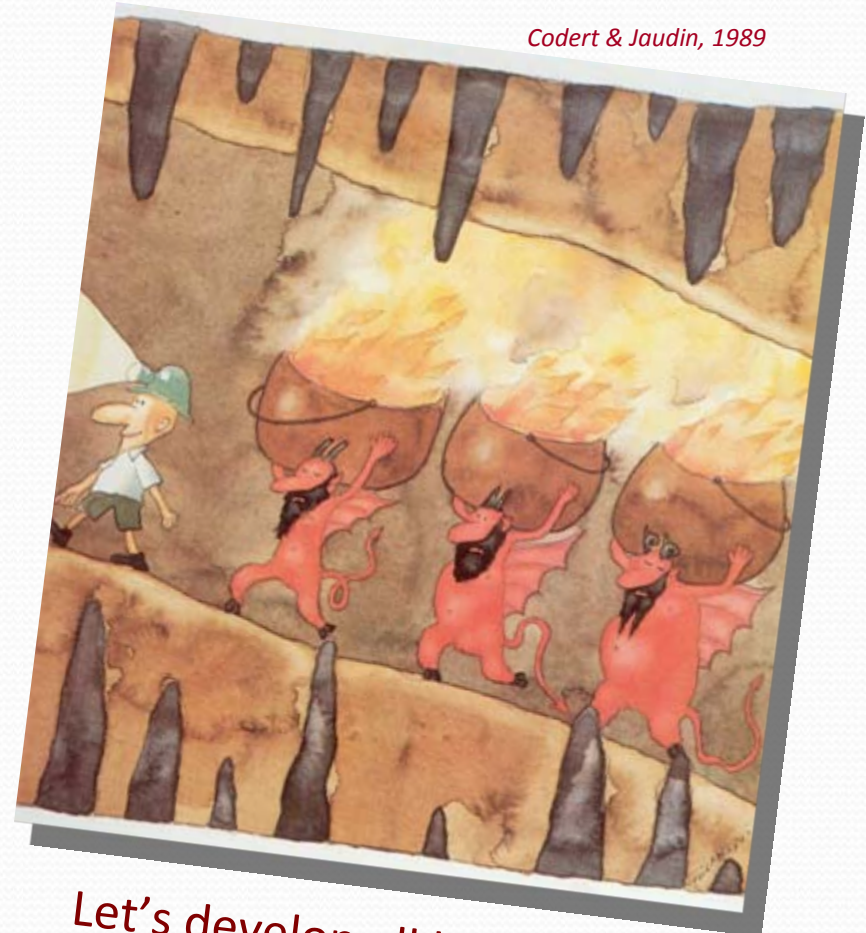
Conclusions

- Geothermal energy is a clean and sustainable source of energy.
- Geothermal energy can be used for power generation and for a variety of direct applications, some of which are related to mining/metallurgical sector.
- This energy source can provide power and desalinated water in remote mining areas
- Other uses include drying of solid materials, extraction of valuable minerals and metals, heap leaching and enhanced oil recovery.
- Finally, it is time to start developing the vast geothermal resources in Milos Is. for water desalination, drying and power generation.



**Thanks for your
attention !**

Codert & Jaudin, 1989



**Let's develop all local and
renewable energy sources!**